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High-Resolution Measurement-Based Phase-Resolved Prediction of Ocean Wavefields

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LONG-TERM GOAL

Given remote and direct physical measurements of a realistic ocean wavefield, obtain a high-resolution description of the wavefield by integrating the measurements with direct phase-resolved wave computations including realistic environmental effects such as wind forcing and wave breaking dissipation. Inform and guide the measurements necessary for achieving this reconstruction and address the validity, accuracy and limitations of such wavefield reconstructions.

OBJECTIVES:

The specific scientific and technical objectives are to obtain:

1. Development of a phase-resolved, deterministic model for nonlinear wavefield reconstruction and evolution at intermediate scale ($O(1) \sim O(10)$ km) using ship-mounted radar wave measurements
2. Characterization and quantification of uncertainty and incompleteness in sensing data on wavefield prediction
3. Incorporation and evaluation of physics-based wind-forcing and wave-breaking models that are developed/calibrated/validated based on simulations and measurements
4. Direct comparison between quantitative measurements and wavefield reconstruction and predictions
5. Development of a comprehensive theoretical framework for wavefield reconstruction and predictability that can guide deployment of wave sensing systems and data interpretation

APPROACH

We develop and apply a comprehensive deterministic model for intermediate scale, $O(10)$ km, wave environment prediction by integrating whole-field and multiple-point direct measurements of the wave and atmospheric environment with nonlinear simulation-based reconstruction of the wavefield. The wave reconstruction is based on phase-resolved simulation of nonlinear surface wave dynamics, and utilizes hybrid (from different types of sensors) measurements that may contain noise, uncertainty and gaps. The simulations will incorporate physics-based wind forcing and wave-breaking dissipation models, which are themselves developed/validated/calibrated based on measurements.

WORK COMPLETED

The major activity in the last fiscal year was planning for the whole project. We attended two planning meetings (held in San Diego in March 07 and June 07) and participated in discussions on key scientific and technical issues that may arise in future field experiments and modeling development. We performed a preliminary investigation on the modeling of wind forcing in phase-resolved simulation of nonlinear wave dynamics. We studied algorithms for reconstructing wave information in the shadow zones of radar measurements using deterministic nonlinear wave simulations. In addition, we developed a detailed proposal to address some of the key scientific and development issues particularly in the area of reconstruction and modeling of realistic ocean wavefields.

IMPACT/APPLICATIONS

Advances in large-scale nonlinear wave simulations and ocean wave sensing have recently made it possible to obtain phase-resolved high-resolution reconstruction and forecast of nonlinear ocean wavefields based on direct sensing of the waves. Such a capability will significantly improve ocean-surface sensing measurements and deployment, and data assimilation and interpretation, by providing a comprehensive wave-resolved computational framework. Another important potential application of this is to greatly increase the operational envelopes and survivability of naval ships by integration of such capability with ship-motion prediction and control tools.